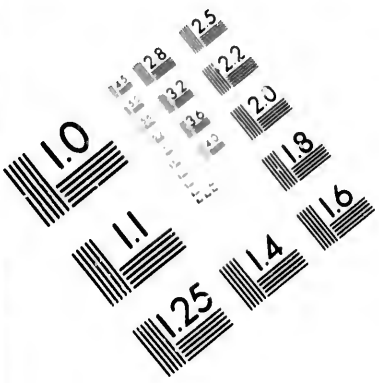

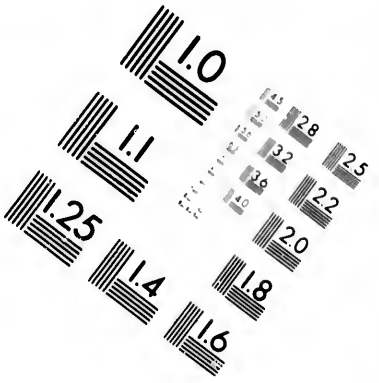

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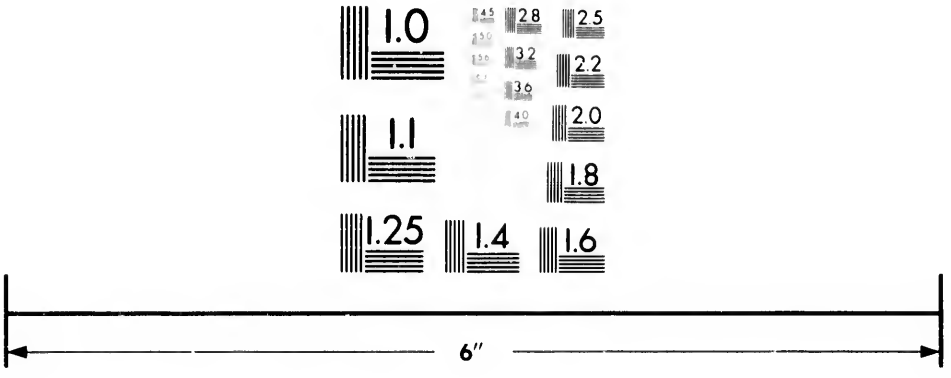

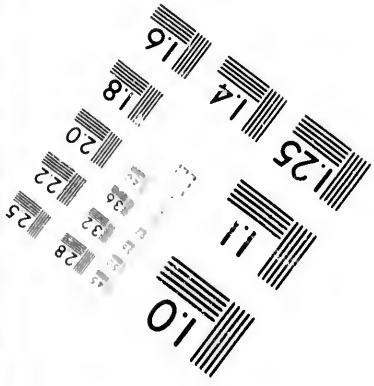

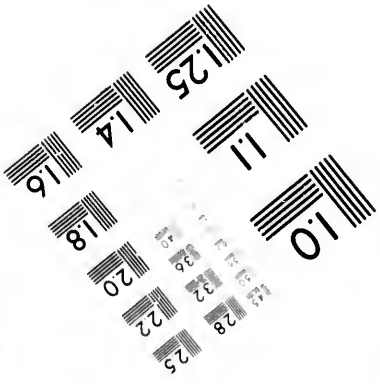

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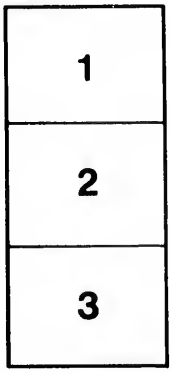

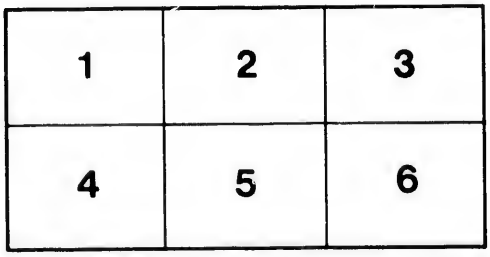

Some Temperatures in the Great Lakes and St. Lawrence.

(Reprinted from the Canadian Record of Science, Vol. IV., No. 2, April, 1890.)

Some Temperatures in the Great Lakes and St. Lawrence.

By A. T. Drummond.

The equalizing influence exerted by great and deep bodies of water upon the climate of the surrounding land is well known. Apart from this general result, the temperature of the water has also a direct effect. On the banks of the Lower St. Lawrence these two effects are well illustrated. Where the cold Labrador current, trending inward from the Straits of Belle Isle, skirts the north shore of the estuary, the little semi-arctic plants are more numerous than on the south shore, where the same current returning outwards carries with it the milder waters which have descended from the Great Lakes and the St. Lawrence. Lake Superior, around whose jutting headlands dwell semi-arctic and northern plants, and west of whose coasts many of the familiar forest trees of Ontario and Quebec do not range, affords another illustration.

The vast area and depth of the St. Lawrence Great Lakes, the different latitudes in which they lie, and their relations to each other, taken in connection with the extremes of heat and cold of the Canadian seasons, combine to give an interest to the temperature of the waters of these inland

seas. Lakes Superior and Michigan may be regarded as two distinct reservoirs—the former of cold and the latter of warmer water—which constitute the largest sources of supply for the lower Great Lakes. Hind found the surface of Lake Superior on 30th July, at noon, as low as 39.50° at fifty miles from land. The outlets of these two lakes into Lake Huron are close to each other, the Michigan waters flowing directly into the main basin of Lake Huron, and the colder waters from Superior, while joining them in part through the detours between the Manitoulin Islands, appearing in part also to find their way eventually to the Georgian Bay by the channels north of the same islands. Now, Lake Huron in its profound depths forms three great basins—the Georgian Bay, the Central and the Southern Basins. The Georgian Bay is separated from the Central Basin, not only by the Bruce Peninsula, but by a continuous sub-aqueous ridge which comes to the surface in islands at different points, whilst under water it presents on the one side bold precipitous cliffs facing the Georgian Bay, and on the other, shelves somewhat gradually towards the deeper waters of the Central Basin. This ridge prevents the free interchange of water between the deeper portions of the Georgian Bay and Lake Huron proper, and makes the former a somewhat isolated basin of cold water without any considerable free current of warmer water flowing into and through it. This isolation aids in retaining in the Bay the colder waters which have accumulated there during the winter months. Thus, whilst the surface in July and August may be as high as 65° F., the bottom temperature at 31 fathoms and upwards, varies between 39.5° and 37.75° F.

The Central and Southern basins of Lake Huron, on the other hand, are separated by the sub-aqueous corniferous escarpment which diagonally crosses the lake in a south-eastern direction from the outlet of Lake Michigan, and which also appears to have its effect on free circulation between the deeper waters of these two basins. In the Central basin, at the bottom in 65 fathoms the temperature in July was 42° F., whilst in the Southern basin at the bottom

in 38 and 45 fathoms it was 52° F. The Southern basin not only lies in a lower latitude, but is much shallower and has a bottom largely composed of sand. Apart from these circumstances, the natural flow of the warm Michigan surface waters is towards and into this basin before their final entrance into the St. Clair River at Sarnia. On the other hand, the tendency of the colder Superior waters constantly flowing into the Central basin and modifying the warm surface waters from Lake Michigan, is to maintain a somewhat lower temperature in the depths of the Central than in the lesser depths of the Southern basin.

In their main expanse, Lake Superior and the Georgian Bay thus constitute in midsummer, great bodies of colder water, whilst the Central basin of Lake Huron in its greater depths also forms a reservoir of cold water, but tempered by the warmer inflow from Lake Michigan.

Lakes Erie and Ontario are, on the other hand, warmer lakes, consequent on their geographical position, their affluent streams from the south and south-west, and the necessarily higher temperature of the larger volume of waters which have flowed over the great shallows of Lake St. Clair before reaching Lake Erie.

Records of observations made by myself during this last summer near the outlet of Lake Ontario, and in the St. Lawrence and other rivers, and by Staff-Commander Boulton, R.N., during last and previous seasons in the Georgian Bay, appear to establish some interesting results which are here appended. It is not assumed that these results are new, but they exemplify some characteristics of fresh water in the great masses in which it occurs in the Canadian Great Lakes and rivers, and under the varying conditions of climate which the geographical position of these lakes and rivers presents.

The instruments used in my observations were:—for surface readings, Negretti & Zambra's Reference Thermometer with Kew corrections, and, for deep water, the same makers' Patent Marine Thermometer, carefully compared with standard instruments. Staff-Commander Boulton's

thermometers were previously tested at the Toronto Observatory.

Motion as Affecting the Temperature of Water.

Some tests made above and at the foot of the rapids in the Richelieu River at Chambly, would seem to show that the motion of the water during the one mile of continuous rapid here, raises the temperature of the water at least perceptibly. Above the rapids at 3 p.m. on 29th August, the air at the surface indicated 80° F., and the water at a depth of 1.5 feet, 73.75° to 74° F., whilst at 3.45 p.m., at the foot of the rapids, with the air at the surface, 75° F., the water in 1.5 feet in the rapids was, in different tests, 74° to 74.5° F. In other words, the water showed an increase of about one-half a degree in the face of the decreasing temperature of the air, as the afternoon wore on. Again, on 7th September, at 4.20 p.m., above the rapids, with the air on the bank registering 66.5° F., the water at 1.5 feet depth indicated 69.75° F. in the sun, while at 5.30 p.m., at the foot of the rapids, the water in the rapids was still 69.75° F., though the sun was clouded and the air on the bank had fallen to 62.5° F.

Rapid currents have, however, the effect of equalizing the temperature of the water. Thus, in June, at Rockport, among the Thousand Islands in the St. Lawrence, where there is a strong current, the water, at nearly 40 fathoms, indicated only 0.5° lower temperature than at the surface.

Areas of Water of Different Temperatures.

Under conditions which appear to be the same, and at points relatively near each other, the water on the surface of the lakes and rivers is not uniform in temperature, but seems to flow in areas of different temperatures—the variation being generally from 1° to 3°. At different depths down to the bottom, there are equally marked variations. In the tributary streams similar results appear. An interesting illustration occurred in a shallow creek, fully

exposed for an eighth of a mile to the sun's rays, and slowly flowing over a succession of limestone ledges, where, in 1.5 inches of water, the mercury on a warm June afternoon could be seen rising and falling between 81° and 83° F. Here there were some exceptional causes, but in the line of outflow from Lake Ontario to the St. Lawrence, the fluctuations are rather to be ascribed to the evaporation at the surface, and to the cooler waters beneath ascending to supply the place of the evaporated water. As the evaporation would be irregular, varying with the passing clouds, the gusts of wind, and the features of the land, the ascending currents would also be irregular. These ascending waters would give rise to a slight inflow at the bottom from deeper and cooler parts of the lake to take their place, and both these currents would be affected by the general onward flow of the lake waters towards the entrance of the St. Lawrence.

Bottom Currents in Georgian Bay.

On 20th August, 1886, Commander Boulton, in a series of soundings diagonally across the centre of the Georgian Bay, in a somewhat southerly direction, found the temperature of the water at the bottom at one point (31 fathoms deep) 39.5° F., at another (47 fathoms) 38.25° F., and at a third (42 fathoms) 37.75° F.—the distance between the extreme points being about 40 miles. On 10th July, 1889, nearer the Bruce peninsula, the readings in 70 fathoms gave 38.75° F., and on 8th September following, at another point in 63 fathoms, the reading was 39° F. In all these different cases, the surface water varied from 59.75° to 68°—the last being on 8th Sept., at 10.10 a.m. As the temperature of water at its maximum density is 39·2° F., and below that, the density again diminishes, there would be a tendency in these bottom strata of water to rise until they intermingled with water of a higher temperature and equivalent density. It is thus necessary to seek some explanation of this singular fact that the bottom temperatures in this extensive bay are in summer as low in places

as 37.75° F. The probability is that there are strong bottom currents which prevent what would be the natural course upwards of the colder and lighter waters of the bottom. Commander Boulton is also inclined to take this view. The two leading physical features which characterize the bottom of the bay, are, first, the somewhat shelving nature of the bottom from east to west, the western side, along nearly its whole length, being remarkably deep, and continuing so up to the very cliffs which bound it, and, secondly, the apparently complete severance of its deeper waters from those of Lake Huron by the submerged escarpment between the Bruce peninsula and the Manitoulin Islands. These two features may be found to have some influence in this connection.

Harbour Temperatures.

The more land-locked a harbour is, the higher is the temperature of its water as compared with that of the water outside of the harbour. It may be equally predicated that, up to a certain point, the more foul the harbour water is, the higher, to a further extent, is the temperature likely to be. At Kingston, this occasionally, in midsummer, is well illustrated. On 10th July last, after two or three days of comparatively calm weather, during which the upturned sediment of the bottom, the floating harbour accumulations, surface drainage, and the sewage appeared to be gathered together in the harbour to an unusual extent, while the mercury at 3000 feet off the wharves indicated 73.5° F. two inches under the surface; it, at 100 feet, rose to 78° F., at the same depth three hours subsequently, though in the meantime the sky had become overcast with clouds. These accumulations contaminate the water for very considerable distances outward in the harbour, and warn us how important to the health of cities and towns, similarly situated, it is to have the water, supplied for domestic uses, taken from points beyond any possible line to which such accumulations may extend. The higher temperature of the harbour

waters would form some objection to their use for household purposes, though not so serious an objection as their contamination.

Temperature in Relation to Depth.

It is impossible to lay down any general rule regarding the changes of temperature with the increase of depth. Apart from variations resulting at the different seasons, surface readings are affected by sunlight and cloud, gusts of wind, channel currents, the inflow of affluent streams, and the physical features of the surrounding land. Readings beneath the surface are affected by the depth of the water, by ordinary currents resulting from changes of level, by evaporation at the surface creating an upward flow of the water underneath, by the contour of the bottom, and by high winds which drive the surface waters before them, creating return currents underneath to take their place. Each case has to be judged by its own special circumstances. Thus, in the Georgian Bay, between Cabot's Head and Cape Croker, Commander Boulton, on 27th July, 1888, at 8.30 a.m., obtained the following record:

Surface	60·2° F.
10 fms	45·7°
20 "	41·4°
35 "	41°
66 " (bottom)	39·5°

On 14th June, 1889, at 11.25 a.m., one mile south-west of Kingston, in the channel from the lake to the river, one of the records was:

Air in sun	79° F.
Surface water	58.5°.
6 feet	56.25°.
18 "	54°.
30 "	54.25°.
60 " (bottom)	52°.

On the 25th July following, at 4.15 p.m., at a point in the same channel, two miles distant, the readings showed not only a higher range, but a much nearer approach between the surface and bottom temperatures, thus:

Air in sun	80° F.
Surface water	69°.
5 feet	68.75°.
12 "	67.75°.
18 "	67.66°.
30 "	67.75°.
72 " (bottom)	67°.

Again, in a very shallow stream on Wolfe Island, lightly flowing over exposed limestone rocks, the air on June 14th, at 3.15 p.m., at three feet above the water, indicated 73° F., whilst the water at 1.5 inches registered 83° F., at 4 inches varied between 79.5° and 82 5° F., and at 7 inches, on the bottom, fell to 72.5° F.

Junction of Affluent Streams.

An illustration of the effects of the warmer waters of the affluent streams on the main body of the St. Lawrence waters, was the case of the Gananoque River at its outlet. The temperature of the bottom near the foot of the fall was, on 10th June, 62.75° F.; a quarter of a mile down stream, at the outlet to the St. Lawrence, it was 61.5° F.; in the St. Lawrence, 150 yards off the outlet, 57° F.; 100 yards west of this, against the current of the St. Lawrence, 56.75° F., and 100 yards still further west 54.25° F. The surface water at these different points varied only between 62.25° and 63° F. The Gananoque River current below the falls is strong, and by a westward deflection of the sandstone banks at the outlet, it is thrown against the much lighter St. Lawrence current, but as above shown, the effect is soon gradually lost at the bottom of the St. Lawrence, however much farther it might be traced at the surface.

Gradual Absorption of Heat.

The general rise in the temperature of Lake Ontario waters as the summer advances is, at first, slow, compared with the general rise in the temperature of the air, but, as midsummer is reached, the rise is more rapid both at the

surface and at the bottom. On June 14th, at noon, when the air indicated 79.75° F., the surface water in the main channel, two miles from Kingston, was still as low as 57.5° F. or only 5° higher than on May 23rd. On July 5th, the readings at the same place and hour had increased to 69.5° F., with the air at 79° F., and on July 10th to 74.75° F., with the air at 92.75° F., the thermometer being always in the sun. The most marked change was between June 25th and July 5th, when the advance registered was 9°. The bottom temperatures indicated somewhat similar results. On May 23, at 13 fathoms, the deep sea thermometer registered 50.25° F.; on June 14, at 12 fathoms, 52° F., on July 10, at 11 fathoms, 62.25° F., and in another spot in 17 fathoms, 53° F., and on July 25, at 12 fathoms, 67° F.

The absorption and retention of the sun's heat is most noticeable in the small streams and quiet pools. There we find well illustrated the general proposition that in high temperatures, the surface of comparatively still water, where unaffected by under currents, absorbs and retains the heat of the sun to a much greater degree than the immediately overlying air. A remarkable illustration has already been given in the case of the lightly flowing but shallow Wolfe Island stream, where the surface water was 7° higher than the immediately overlying air, and 10° higher than the air at 3 feet above, whilst on the bottom, at 7 inches in depth, the temperature fell again to 10.5° below that of the surface water. The records of other creeks did not indicate such extremes, but showed that each stream in its bottom, current and surroundings, may have circumstances which vary the temperature. In very shallow, still pools, exposed freely to the sun and breeze, but almost isolated from the main stream, the difference between the temperature of the surface of the water and of the immediately overlying stratum of air, is, however, sometimes still more marked, the water on sunny afternoons in June and July showing over 11° higher range. In such pools, the water, though indicating variation, is tolerably uniform even to the bottom.